ERIC Document Resume	See Instruction Sheet	DATE OF RESUME 6/3/65	DATE RECEIVED

A. PUBLICATION DATA

1. ERIC NUMBER	2. ORIGINATOR CONTROL NO(S).	3. IDENTIFICATION NO.	DO NOT WRITE IN SPACE BELOW
ED000665	8109		

4. AUTHOR(S):
Harmon, Lindsey R.

5. TITLE OF DOCUMENT ABSTRACTED:
The Effect of Fellowships on Acceleration of PhD. Attainment: Technical Report No. 14

6. PUBLICATION TITLE:
N.A.

7. EDITOR(S):
N.A.

8. PLACE OF ORIGIN
ORG. OSP, NA S, NRC
ST. Washington, DC
CITY/STATE

9. PUBLISHER OR SOURCE
Office of Scientific Personnel, Nat. Academy of Sciences - Nat. Research Council

10. VOL.	11. PAGES	12. MO./YR.	13. CONTRACT
N.A.	N.A.	Jan. 59	13

TELE. EXT.
INST/LCC CODE

MICROFILM COPY AVAILABLE YES ☒ NO ☐
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TYPE OF REPORT
PROPOSAL ☐
IN-PROGRESS ☐
FINAL ☒
FOLLOW-UP ☐
OTHER ERIC REFERENCES:
ERIC SATELLITE CODE

B. INDEXING DATA

14. SUBJECT AREA

15. TYPE OF ENDEAVOR
experimental study

16. INDEXING TERMS (8-12)
experimental studies, degrees, students, higher education, financial aid, science education, graduate education, fellowship, programs

17. ABSTRACT (MAX. 280 WORDS)

An investigation of the validity of the assumption that the awarding of fellowships accelerates the attainment of the doctorate degree and increases the total number of students completing their graduate training. In the study, 555 male applicants for Atomic Energy Commission fellowships in science in 1949 were followed up in 1958 to determine which ones had completed doctorate-level training and when. All candidates, both awardees and those not granted fellowships, were sorted into groups relatively homogeneous as to initial level of ability and initial level of academic attainment. Biological and physical science groups were investigated separately, and the results for the two science fields were combined where possible.

Findings revealed that when verbal and quantitative ability and initial academic status are controlled, the award of a fellowship is significantly associated with earlier completion of the Ph. D. degree. The fellows, on the average, completed their degrees more than a year earlier than did the nonfellows. Also, a significantly larger number of fellows attained the Ph. D. degree by the end of 9 years.

ERIC No.

18. SOURCE OF ABSTRACT
Reporter No. 6

C. FUNDING DATA

19. SUPPORTING ORGANIZATION	20. DIVISION OR DEPT.	21. CONTRACT NO. / PROJECT NO.
	22. TOTAL COST OF PROJECT	
	23. DURATION OF PROJECT	U.S. Department of Health, Education, and Welfare Office of Education

ERIC Form 1

R-6-12
x 10.21

Alice L. Richards

8109

TECHNICAL REPORT NO. 14
15 January 1959

Research on
Fellowship Selection Techniques
Supported by the
National Science Foundation

THE EFFECT OF FELLOWSHIPS ON ACCELERATION OF PH.D. ATTAINMENT

by Lindsey R. Harmon

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education

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Office of Scientific Personnel
National Academy of Sciences-
National Research Council
Washington, D. C.

ED000665

15 January 1959

BRIEF OF TECHNICAL REPORT # 14

Fellowships are made available to highly-qualified graduate students on the assumption that the fellowship will accelerate the attainment of the doctorate degree and will increase the total number of students completing their graduate training. Is this assumption correct? The present study investigated this question.

555 men applying to the Atomic Energy Commission in 1949 for fellowships in science were followed up in 1958 to determine which ones had completed doctorate-level training, and when. All candidates, both awardees and those not granted fellowships, were sorted into groups relatively homogeneous as to initial level of ability and initial level of academic attainment. Biological and physical science groups were investigated separately, and the results for the two science fields combined where possible.

The results of the study show that when verbal and quantitative ability and initial academic status are controlled, the award of a fellowship is significantly associated with earlier completion of the Ph.D. degree. The Fellows, on the average, completed their degrees more than a year earlier than did the Non-fellows. Also, a significantly larger number of Fellows attained the Ph.D. degree by the end of 9 years. Similar results are found for women, although the number of cases in the latter group was not large enough for reliable statistics. In an ex post facto analysis such as this, causation cannot be unambiguously determined from the observed association. It may be said, however, that either the award of a fellowship itself resulted in the acceleration, or the selection boards did a very good job in selecting those whose ability (apart from the verbal and quantitative ability, which was controlled) permitted them to progress more rapidly.

THE RELATIONSHIP BETWEEN AWARD OF A FELLOWSHIP AND ACCELERATION IN COMPLETION OF THE PH.D.

The problem investigated in the current study was whether the award of a graduate fellowship is related to the acceleration in the attainment of the Ph.D. degree, and if so, to what degree.

The fellowship program with whi.h we are here concerned is that conducted by the National Science Foundation. When the NSF was set up in 1951, it carried forward, in effect, a fellowship program initiated in 1948 by the Atomic Energy Commission. The procedures used from 1949 on in the AEC program were much the same as those currently employed in the NSF program, and any results from the former should generalize to the latter. Because in any such study as that here described, a period of time must elapse between application for a fellowship and attainment of the doctorate degree, it is desirable to initiate such a study with the earliest data available -- in this case the 1949 AEC candidates. It is planned that a similar analysis will later be accomplished in respect to the NSF candidates.

The cases included were the 1949 Atomic Energy Commission predoctoral candidates. There were altogether 555 men, including 382 of the physical sciences, of whom 221 got awards, and 173 of the biological sciences, 76 of whom got awards, for a total of 297 awardees and 258 non-awardees. (There were a small number of women, but the cases were too few and too scattered to permit analysis). The date of attainment of the Ph.D. degree was ascertained from the Doctorate Records files of the Office of Scientific Personnel.

Because the candidates included people at all eligible educational levels, from college seniors about to enter graduate work to those within a year of the Ph.D., it was necessary to sort them out by educational level. The cases were divided into three groups roughly corresponding to the levels 1, 2, and 3 of the current NSF fellowship program, although these levels had not been determined originally under the AEC program. For the purpose of this study, these levels were modified somewhat, so as to have approximately the same number of cases at each level.

The boards that awarded the fellowships were obviously guided in making the awards by information relating to the candidates' abilities. It was, therefore, important to establish at least a partial control on educational aptitude in order to sort out the effect of award as such from the correlated effect of higher academic ability on the part of the awardees. The verbal and quantitative tests of the Graduate Record Examination were employed for this purpose, as they formed a single set of measures which were comparable across all candidate groups. Three ability groups of approximately equal numbers were established by sorting the cases on the sum of the percentiles on the verbal and quantitative tests. Other measures of ability available to the selection boards included a test of educational achievement in the candidate's own field, a transcript of college (and graduate school, when available) grades up to the time of application, and confidential reports from the students' professors. All of these latter measures, while important indices of ability, were more or less specific to the candidate's special field or circumstances, and hence were not strictly comparable across all candidates. It was because of these limitations on their com-

parability that they were excluded from the index of ability used in this study, not because of any assumption that they might be unimportant.

A third control, based on field of specialization, was also established. Originally separate boards in the biological and physical sciences had evaluated the fellowship candidates. It is apparent from the study of these records that the candidates in the two fields varied markedly in academic ability. It is probable also that the boards varied somewhat in their selection standards, simply because they operated independently. The follow-up data indicates that the two groups attained Ph.D.'s at different rates. For all of these reasons, it was not feasible to combine the two groups into a single one for the present investigation. We thus have two similar but independent experiments on the effect of award of a fellowship.

The Ph.D. Attainment Criterion.

In order to have a quantitative criterion that is easy to manipulate in a statistical analysis, and in which a high score represents high achievement, the following scale was established for evaluation of date of Ph.D. attainment:

Date of Ph.D.:	1949	1950	1951	1952	1953	1954	1955	1956	1957-58	None
Crit. Scale Val.:	9	8	7	6	5	4	3	2	1	0

This scale was applied to the 36 groups obtained by dividing the whole fellowship candidate population by field, by educational level at the time of application, and by scholastic aptitude groups, and finally sorting into award and non-award categories. The mean score on this criterion scale was computed for each group, and the differences between awardees and non-awardees were calculated. The results are presented in Table 1 for the physical sciences and Table 2 for the biological sciences.

The mean differences appear rather consistent, with only one reversal in each table. These mean differences are in the expected direction, with the awardees achieving their degrees earlier than the non-awardees, even when the factors of level and ability are held constant. The tables also present the data for the levels, combining all ability groups within each level, and for all cases within each field, ignoring both level and ability. To summarize these results in a single table easier to follow, Table 3 was constructed, presenting the average effects. It must be noted here that Table 3 was constructed from the average of averages, without weighting them according to number of cases involved. One cannot, therefore, make accurate estimates of the margin of error in these data.

Table 1

Numbers of Cases and Mean Criterion Scores By Levels & Ability Groups
Physical Science Awardees and Non-Awardees

Educ. Level at Applic.	Abil. Group	Numbers Awardees	Numbers Non-Awardees	Mean Criterion Score Awardees	Mean Criterion Score Non-Awardees	Diff.
3	High	32	12	7.25	5.83	1.42
3	Med.	32	14	7.53	6.71	.82
3	Low	25	18	7.52	5.89	1.63
3	Total	89	44	7.43	6.14	1.29
2	High	35	8	7.03	5.25	1.78
2	Med.	23	14	7.22	6.36	.86
2	Low	22	19	6.27	6.26	.01
2	Total	80	41	6.88	6.10	.78
1	High	26	12	6.19	3.75	2.44
1	Med.	17	28	5.53	4.29	1.24
1	Low		36	4.00	4.39	-.39
1	Total	52	76	5.60	4.25	1.35
All Levels H M L		221	161	6.80	5.24	1.56
		382		6.14		

Table 2

Numbers of Cases and Mean Criterion Scores By Levels & Ability Groups
Biological Science Awardees and Non-Awardees

Educ. Level at Applic.	Abil. Group	Numbers Awardees	Numbers Non-Awardees	Mean Criterion Score Awardees	Mean Criterion Score Non-Awardees	Diff.
3	High	14	5	7.29	7.40	-.11
3	Med.	13	11	6.85	6.36	.49
3	Low	3	12	7.00	5.42	1.58
3	Total	30	28	7.07	6.14	.93
2	High	15	3	5.93	4.00	1.93
2	Med.	8	16	6.25	4.19	2.06
2	Low	4	15	4.75	2.80	1.95
2	Total	27	34	5.85	3.56	2.29
1	High	10	6	4.50	3.17	1.33
1	Med.	6	6	4.67	1.67	3.00
1	Low	3	23	4.33	3.00	1.33
1	Total	19	35	4.53	2.80	1.73
All Levels H M L		76	97	6.00	4.03	1.97
		173		4.90		

Table 3

Average Effects of Award of Fellowship, By Level

Level	Physical Sciences	Biological Sciences	Both Fields Combined
Level 3	1.29	.93	1.11
Level 2	.78	2.29	1.54
Level 1	1.35	1.73	1.54
All Levels	1.14	1.65	1.39

The gains shown in Table 3 appear to be stable differences. However, this is but a subjective judgment, and should be checked by objective means. Tests of significance are available, and scientific caution requires that they should be applied to determine whether differences of this magnitude are reliable. With data of this complexity, several tests might be made. We have chosen two. One is a simple and quick test that gives a measure of over-all significance and some indication of where the most reliable differences occur. The other is a more elaborate and precise measure which might be expected to yield a more comprehensive statement of the conclusions which may legitimately be drawn.

Chi-Square Analysis

The first test is a chi-square (X^2) analysis involving all the data after some combining to yield groups large enough for reliable analysis. It was done separately for the biological and physical groups. At each educational level, the awardee and non-awardee groups were divided into those relatively "fast" or "slow" in attainment of the Ph.D. In the physical science group the number of cases was large enough to yield an intermediate or average group. In the biological group a dichotomy only was feasible because of the relatively small number of cases. The definitions of these "relative speed" groups are as follows:

Physical Sciences	Fast	Medium	Slow
Level 3 - attained Ph.D. by	1949	1950	all others
Level 2 - " " "	1950	1951	" "
Level 1 - " " "	1951	1952	" "

Biological Sciences	Fast	Slow
Level 3 - attained Ph.D. by	1951	1952 or later
Level 2 - " " "	1952	1953 " "
Level 1 - " " "	1953	1954 " "

After thus sorting the total group into fast, medium, and slow groups, they were sub-divided, as before into high, medium, and low ability groups, and sub-divided into awardee and non-awardee categories. In this analysis, the three levels were combined at this point, with a tabulation resulting as shown in Table 4. It was on this table that the X^2 analysis was performed.

In computing X^2, the observed frequencies (O) are compared with a set of computed frequencies (C). These latter frequencies are computed according to

the hypothesis that the award of a fellowship is unrelated to the rate of completion of the doctorate. The X^2 statistic affords a test of this assumption: a high X^2 value indicates that the difference is larger than could be expected on the basis of chance variations alone, and the hypothesis would have to be rejected.

Table 4

Computation of Chi-Square for the Effect of Award of Fellowship

			Physical Sciences		Biological Sciences	
			Observed O	Computed C	Observed O	Computed C
High Ability	Fast	Awardee	32	24.55	30	23.5
		Non-Awardee	1	8.45	8	14.5
	Med.	Awardee	35	35.71		
		Non-Awardee	13	12.29		
	Slow	Awardee	26	32.74	9	15.5
		Non-Awardee	18	11.26	16	9.5
Chi-square sum for high ability:				14.31		11.88
Med. Ability	Fast	Awardee	24	20.82	22	16.2
		Non-Awardee	13	16.18	14	19.8
	Med.	Awardee	27	21.96		
		Non-Awardee	12	17.04		
	Slow	Awardee	21	29.22	5	10.8
		Non-Awardee	31	22.78	19	13.2
Chi-square sum for medium ability:				9.05		9.44
Low Ability	Fast	Awardee	17	14.32	6	4.2
		Non-Awardee	16	18.68	15	16.8
	Med.	Awardee	22	18.68		
		Non-Awardee	21	24.32		
	Slow	Awardee	17	23.00	4	5.8
		Non-Awardee	36	30.00	25	23.2
Chi-square sum for low ability:				4.69		1.66
Over-all chi-square:				28.05		22.98

In Table 5, the probability levels of X^2 are shown in the right hand column. As may be seen, these probability values vary from 1 chance in 5 to fewer than 1 chance in 2000. Table 5 also presents the values of another statistic, the contingency coefficient, computed from the X^2 values, in order to indicate the intensity of the relationships involved. Chi-square itself indicates only the probability level of a relationship. For purposes of a rough approximation, the contingency coefficient may be interpreted as approximately analogous to a correlation coefficient. The formulas for the two statistics are as follows:

$$X^2 = \Sigma \frac{(O-C)^2}{C} \qquad \text{Contingency Coefficient} = \sqrt{X^2/N+X^2}$$

From the pattern of chi-square values, it appears that the impact of the award of a fellowship is greatest at the higher ability levels. In order to interpret these values in terms of relative intensity of the relationship between award and progress, and to provide a statement of the statistical significance of each of them, Table 5 was constructed, summarizing and combining the data for both the physical and biological sciences.

Table 5

Contingency Coefficients Showing Relationship Between Fellowship Award and Academic Progress

Group Included		N	d.f.	X^2	Contingency Coefficient	Significance Level
Physical Sciences	High	125	2	14.31	.32	.001
	Medium	128	2	9.05	.26	.011
	Low	129	2	4.69	.19	.1
	Total	382	6	28.05	.26	<.0005
Biological Sciences	High	63	1	11.88	.40	.001
	Medium	60	1	9.44	.37	.003
	Low	50	1	1.66	.18	.2
	Total	173	3	22.98	.34	<.0005
Both Fields Combined	High	188	3	26.19	.35	<.0005
	Medium	188	3	18.49	.30	<.0005
	Low	179	3	6.35	.19	.1
	Total	555	9	51.03	.29	<.0005

It seems quite clear from Table 5 that there is a statistically significant and reasonably strong relationship between award and rate of progress to the attainment of a Ph.D. at the high and medium ability levels, but only a minor and uncertain relationship at the low ability level. The data of these tables did not themselves explain why the award of a fellowship to the more capable candidates produced a more profound effect. It seems quite possible, however, that what is involved here is actually not the effect of only the initial fellowship award, but also of renewals, and that the more capable students have received more renewals, thus furthering their academic acceleration.

Analysis of Variance

A more precise test of the significance of the award of a fellowship is afforded by use of the analysis of variance technique. What we have done in this case (insofar as is feasible post hoc) is to set up the conditions that would have obtained, had a controlled experiment been performed at the time of the original awarding of the fellowships. The object of the experiment is to make a comparison between people of equal ability (as measured here) and equal educational level who were awarded fellowships, and those who were not awarded fellowships. This cannot be done in a real life situation because of the requirement that awards be made on the basis of ability. This requirement is eminently reasonable and desirable as an operational practice, but imposes a limitation on experimental studies. It is the latter with which we are concerned in the present instance.

Various ability indices might be used in this analysis; in the present case, the sum of the percentiles on the verbal and quantitative tests was employed. As has been mentioned, in the operating situation the panels had available a number of other measures of ability, and by the nature of the operation of panels, they exercised their judgment in each individual case as to the over-all configuration of the data which caused them to decide to award or to withhold a fellowship. This being so, their judgment was not perfectly correlated with the ability index which we have employed. It would, of course, not be perfectly correlated with any index, however chosen. The departure from a perfect relationship with the chosen index provides us, however, with the opportunity for an "artificial" controlled (or partially controlled) experiment. That is, from the observed data we can select groups of people matched with respect to educational level and measured ability, but differing with respect to award of a fellowship. Since awards were given more often to people with high measured ability than to people with lower measured ability, the cell frequencies are not proportional to the marginal frequencies (cf. Table 1). Such disproportionality invalidates the usual analysis of variance procedures. There are approximate methods for analyzing such data (e.g. the method of proportional subclass numbers, the method of unweighted means, etc.), but because of the large sample sizes we chose instead to discard randomly some of the excess cases. The goal set for the physical sciences was to have 14 individuals in each cell, and for the biological sciences 6 individuals in each cell. In a few instances it was necessary to add in artificial cases to bring the cell frequencies up to a fixed number. These added cases essentially duplicated in mean score the ones already in the cells, but with a margin of random error such that the final distribution of criterion scores within these augmented cells was an unbiased estimate of what would have happened had there been enough real cases to fill each category. The number of such added cases was small (a total of 15 in physical sciences and 12 in bio sciences) and did not affect the point at which the table of F was entered.

It should be noted at this point that the use of this limited measure of academic ability results inevitably in a probably small but undetermined bias in the statement of the effect of ability on the criterion scores. A more nearly perfect measure of ability would show a wider difference between the awardees and non-awardees. Any post hoc control would, however, be incomplete, and would leave a portion of the ability component (as viewed by the selection panels) in the category of award-non-award variance. That is to say, the ability difference is understated in the statistics of this analysis.

The academic ability of the "high" non-awardees is overstated and of the "low" non-awardees is understated. This is the familiar phenomenon of statistical regression which always occurs when selections are made, as here, of extreme cases. On an imperfectly correlated measure, they will be less extreme. Thus, if there is a real but not very high relation between the ability measure and the criterion of academic progress, it will tend to be understated in the ensuing analysis.

The end result of this selection and addition process was, for each field, a table of 18 cells, three for each level, three for each ability category, and two for each award status. Within each of these cells, the mean criterion was computed. The result is shown in Table 6. It will be noted that this table is similar to Tables 1 and 2, but that the number of cases in each group is constant.

The analysis of variance provides us a means of determining whether various elements of a situation are related to the outcome to a statistically significant degree. This is done by isolating the amount of variation within a group of cases that may properly be attributed to each of the factors under investigation. In each case then, there is a test of whether the variation so isolated is larger than can normally be expected on the basis of chance alone with the numbers of cases that are involved in the particular experiment.

In the present case, we are interested in isolating the effect of three factors on date of attainment of the Ph.D.: (1) the effect of award of a fellowship, (2) the effect of level of academic attainment at the time of application, and (3) the effect of academic ability of the candidates. It is apparent, of course, that those candidates who are more advanced in their training at the time of application will have the earliest dates of graduation. However, as rate of progress varies considerably, this relationship is far from perfect. In order to isolate from the total amount of variation in date of Ph.D. the amount which is attributable to each factor, it is necessary to determine quantitatively the effect of academic level, so that it can be subtracted from the rest of the variation. We can then determine how much of what remains can be accounted for by ability and by award of fellowship. We are, in addition, interested in determining the combined effects of the two or more factors operating together. This is commonly termed interaction. The findings of the chi-square analysis also suggest that we determine the interaction of award status and ability of the candidates.

A summary of the results of the analysis of variance computations is presented in Table 7, for both the physical science and the biological science candidates. The first column of Table 7 describes the various categories or sources of the variation in date of attainment of the Ph.D. that have been isolated in the present analysis. The first line of Table 7 represents the variation found between levels. The differences here are significant, as indeed they must be because Level 3 cases were mostly in what was expected to be their terminal year, and Level 1 cases were mostly just entering graduate school. Line 2 indicates the amount of variance found associated with the ability groups. Here the lack of a difference is unexpected. This may be due in part to the definition of ability; had it been more inclusive, it is quite possible, if not probable, that the differences between ability groups would have been large enough to have been statistically significant. The third line indicates the variance associated with award of fellowship. This, as expected,

Table 6

Mean Scores of Bio Science and Physical Science Cases Used in Analysis of Variance in Academic Criterion

Level at Applic.	Ability Group	No. of Cases Award	No. of Cases Non-Award	Mean Criterion Score Award	Mean Criterion Score Non-Award
		Physical Sciences			
3	High	14	14	6.93	5.93
3	Medium	14	14	7.21	6.71
3	Low	14	14	7.50	5.50
3	Total	42	42	7.21	6.05
2	High	14	14	6.79	5.57
2	Medium	14	14	7.29	6.36
2	Low	14	14	6.71	5.79
2	Total	42	42	6.93	5.91
1	High	14	14	6.00	3.79
1	Medium	14	14	5.50	4.29
1	Low	14	14	3.92	4.14
1	Total	42	42	5.14	4.07
All	H M L	126	126	6.42	5.34
		Biological Sciences			
3	High	6	6	7.83	7.50
3	Medium	6	6	6.33	6.00
3	Low	6	6	7.00	5.67
3	Total	18	18	7.06	6.39
2	High	6	6	6.00	3.67
2	Medium	6	6	6.33	3.33
2	Low	6	6	4.33	4.33
2	Total	18	18	5.56	3.78
1	High	6	6	5.17	3.17
1	Medium	6	6	4.67	1.67
1	Low	6	6	4.33	3.00
1	Total	18	18	4.72	2.61
All	H M L	54	54	5.78	4.26

Table 7

Summary of Analysis of Variance in Ph.D. Attainment Criterion

	Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio	Signif. Level	Interpretation of F Test
			Physical Sciences				
1	Between Levels	207.65	2	103.83	18.51	P<.01	Levels not homog.
2	Between Ability Groups	17.06	2	8.53	1.52	P>.05	Ability Groups are homogeneous
3	Between Awardees and Non-Awardees	74.48	1	74.48	13.28	P<.01	Aw. and Non-Aw. are dissimilar
4	Interactions	38.03	12	3.17	.57	---	No significant interactions*
5	Within Groups	1312.45	234	5.61	--	---	---
6	Total Sample	1649.66	251	--	--	---	---
			Biological Sciences				
1	Between Levels	174.29	2	87.14	13.22	P<.01	Levels not homog.
2	Between Ability Groups	14.86	2	7.43	1.13	P>.05	Ability Groups are homogeneous
3	Between Awardees and Non-Awardees	62.26	1	62.26	9.44	P<.01	Aw. and Non-Aw. are dissimilar
4	Interactions	41.22	12	3.44	.52	---	No significant interactions*
5	Within Groups	593.34	90	6.59	--	---	---
6	Total Sample	885.96	107	--	--	---	---

* The several types of interaction were tested separately; none were significant.

is significant. It must be recalled, however, that this figure includes that portion of total variance which is associated with ability differences not taken into account by our ability formula, but which was acted upon by the selection boards in making the awards. The fourth line represents the interactions between the awards, levels, and ability groups. For purposes of tabular economy, the four kinds of interaction (three pairs and three factors acting together) were listed on one line. The individual interactions were tested and none found to be significant. The fifth line represents average variance found within the 18 cells, and the last line the total variation from all sources. All of the above definitions apply to both the physical and biological science groups, and the findings and interpretations are similar in both cases.

The finding that there is not a significant amount of variance attributable to membership in the ability groups contradicts the findings of chi-square analysis, and warrants some special discussion.

The uncertain effect of ability in this analysis may be attributed in part to the fact that the selection of cases for this analysis was random rather than systematic, and just by chance did not reproduce the variation found in the total group upon which the chi-square analysis was performed. The smaller number of cases per cell also of course reduces the statistical significance of a difference of a given size. Furthermore, the method of computing the criterion was different in this case from that used in the chi-square analysis. In the earlier analysis, all "slow" cases were grouped together, including those who have never obtained the doctorate. In the analysis of variance, a quantitative measure of rate of attainment was used, and the failure to attain the Ph.D. was given a zero score on this attainment criterion. It is entirely possible that this different way of measuring the outcome played a part in the differing results obtained. However, the major reason for the lack of statistical significance may well be the fact of statistical regression, mentioned earlier in the description of the process of selection of the sub-samples for the analysis of variance test. It should be noted that there <u>is</u> an effect due to ability of candidates, but that is does not reach the 5% level of confidence that we have chosen for our criterion of statistical significance. Had the factors mentioned above not been present to understate the effect of ability, it would very likely have reached a level that would be accepted as statistically significant. There may be an error, in other words, in our significance statement in this case. It would be unwarranted to infer that measured ability makes no difference or that it might as well be neglected in award of fellowships, or that the type of ability measures here used is not valid. Such inferences would be particularly erroneous in view of the limited nature of the criterion of achievement here employed.

The effect we are most interested in in the present study is the relationship between award of a fellowship and speed in attainment of the doctorate degree. Line 3 of Table 7 presents the evidence with regard to the statistical significance of the speed-up effect which is apparent by inspection of Table 3 or Table 6. The F test here is highly significant, showing that the acceleration is far greater than could be expected on the basis of chance variations alone. This finding is, of course, only additional confirmation of the high degree of confidence already established by the fact that of the 9 comparisons within each field all but one comparison in each field were favorable, i.e. showed greater acceleration of the awardees. In the original data (Tables 1 and 2), based on all of the cases, there was one difference in favor of the non-awardee group in each of the fields; through the operation of chance in the selection process, one of these reversals drops out in the reduced data of Table 6. It should be noted, in interpretation of this relationship, that there is included here with the undoubted effect of award <u>per se</u> the associated effect of any superior abilities the awardees possessed that were not accounted for by the verbal and quantitative tests.

One might well note at this point that the possible inflation of criterion scores associated with award of an AEC fellowship may be in part offset by the fact that some of the non-awardees may have received fellowships from other sources. These other fellowships (by schools, foundations, etc.) were not reported and hence could not be accounted for in the present study. One cannot say, however, whether this source of negative bias may equal or exceed the

positive bias due to incomplete control of the ability factor. Its existence, however, should be noted as tending to understate the effect of award of an AEC fellowship.

Total Ph.D.'s Completed

The data up to this point has concerned the rate of completion of Ph.D.'s. A further question may well be asked: Does award of a fellowship have a significant relationship to total degrees obtained, regardless of the time it takes to attain them? An answer can be found in a further break-out of the data, based on the assumption that by now all degrees have been attained that will ever be attained. This assumption can hardly be strictly true, but the decline in rate (only 8 degrees were awarded in the last two years, and a total of 73 have not yet attained degrees, out of 555 men in all originally) indicates that it is approximately true.

In order to control ability level, and still leave numbers of cases in each category large enough for statistical analysis, the physical and bio science groups were merged, the "High" and "Medium" ability groups were combined, and the "Low" group considered separately. The two groupings thus formed were separated into awardees and non-awardees, and further divided into those who had and those who had not yet attained the Ph.D. Table 8 indicates the result.

Table 8

Relation Between Fellowship Award and Eventual Attainment of Ph.D.

	High Plus Medium Ability			Low Ability			All Cases Combined		
	Doctorate Category			Doctorate Category			Doctorate Category		
	Yes	No	Total	Yes	No	Total	Yes	No	Total
Awardees	221	10	231	58	8	66	279	18	297
Non-Awardees	111	24	135	92	31	123	203	55	258
Total	332	34	366	150	39	189	482	73	555
Chi-square		18.29			4.49			22.78	
Probability level		< .0005			.035			< .0005	

It is apparent from this table that award of a fellowship is significantly related to the number of Ph.D.'s finally achieved. This finding significantly supplements the earlier finding that award of fellowship is associated with acceleration in the rate of attainment.

A Note About the Women

Although there were very few women -- too few for a full-scale analysis -- an inspection of the data here tends to confirm the trends shown in the analysis of the data on the men. In the biological sciences only were there comparable cases in the award and non-award groups. Here, too, there seems to be no clear relationship between the Ph.D. attainment criterion and ability. There is, however, a clear-cut relationship between level and the criterion and between award status and the criterion. When a compensation is made for

the difference between levels, and all ability groups are combined, there is a difference of 2.7 years between the awardees and non-awardees. These adjusted criterion means are 4.92 for the former and 2.19 for the latter (both corrected to the level 2 status).

Conclusions

Two significant conclusions may be drawn from this study of the records made by awardees and non-awardees among the candidates for AEC fellowships in 1949. The first is that award of a fellowship is clearly associated with acceleration of the academic progress of the Fellows. On the average, the Fellows in the physical sciences attained their Ph.D.'s slightly over one year earlier than did those not awarded a fellowship. In the biological sciences the effect was even greater, being a year and a half on the average. The second conclusion is that the total number of persons completing the Ph.D. is significantly related to award of a fellowship.

Although an ex post facto analysis of this kind cannot unambiguously state that the acceleration was caused by award of the fellowship, it can state that either this was the cause or that the selection boards did a very good job in choosing for award those people whose abilities (apart from measured verbal and quantitative aptitudes) caused them to complete their training earlier and in larger numbers than was true of the non-awardees. This conclusion is one of considerable operational significance at a time when the shortage of technically trained personnel emphasizes the need for completion of training of talented people as expeditiously as high quality standards permit.